



*... for a brighter future*

# WAKEFIELD TRANSFORMER RATIO ENHANCEMENT EXPERIMENT AT AWA FACILITY\*

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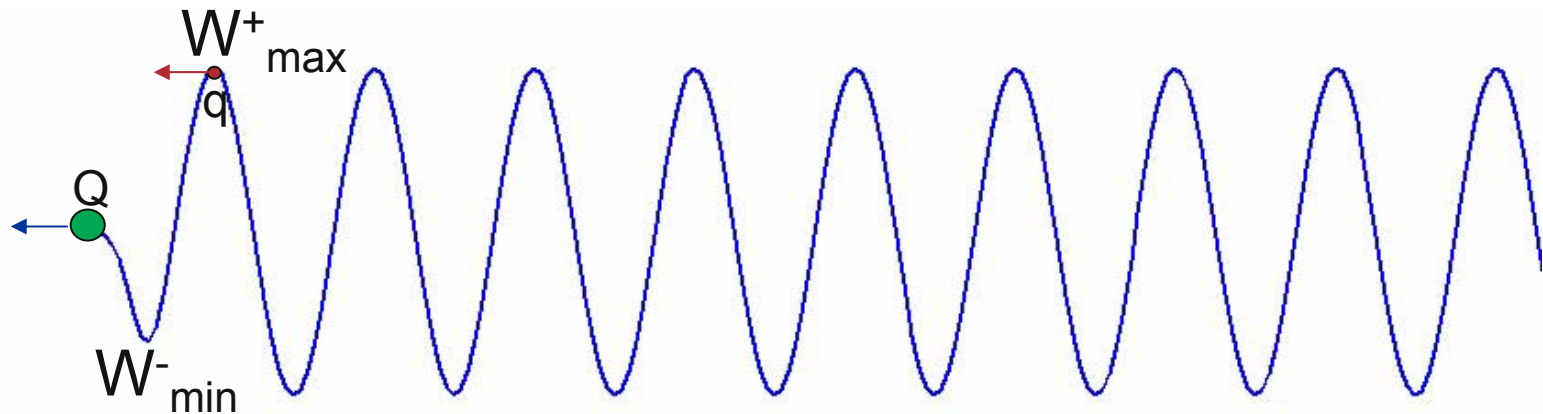
DoE Review, April 26<sup>th</sup>, 2007

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# Introduction

Motivation: a fundamental physical study of the wakefield theory\*.

$$\text{Transformer ratio } R = \frac{\text{Max energy gain of the witness bunch}}{\text{Max energy loss of the drive bunch}}$$

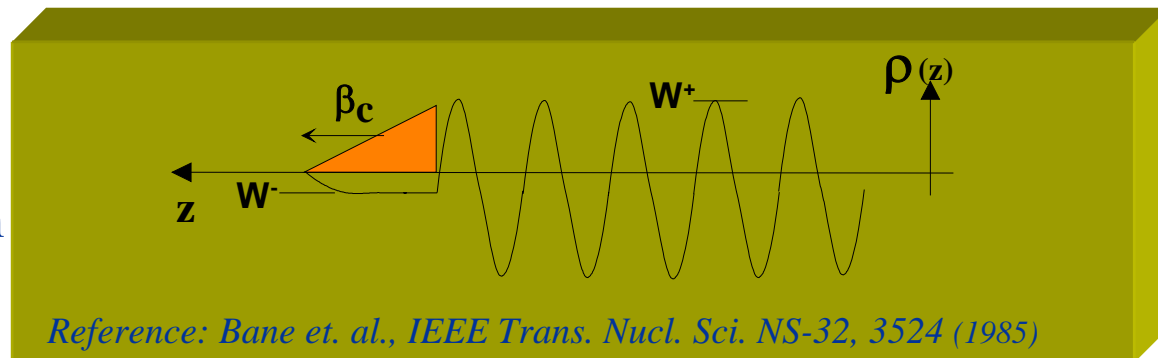


Transformer ratio limited:  $R \leq 2$  @ a longitudinally symmetric drive bunch, but it can be enhanced greater than 2 using asymmetric bunch.

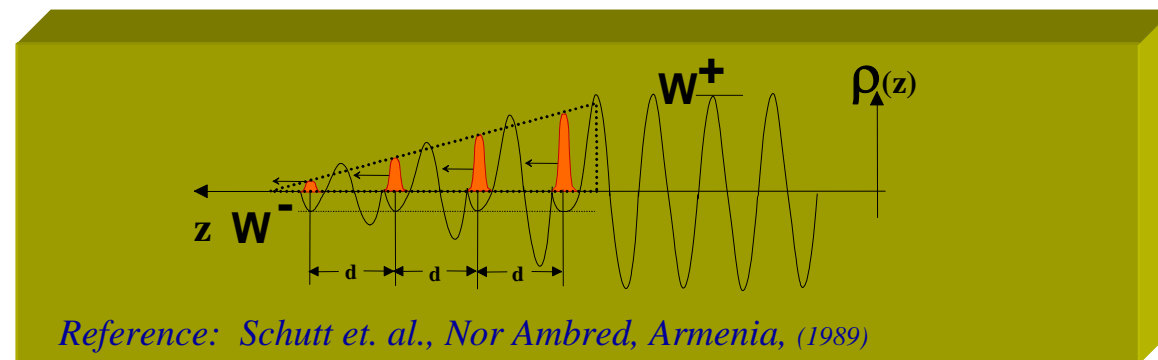
\* Results was published in Phys. Rev. Lett. 98 (2007) 144801.

# Ideas

## Scheme I---Single Triangular Bunch



## Scheme II---Ramped Bunch Train



RBT:  $d=(1+1/2)\lambda$ , acceleration for the second bunch,  $Q_1=3Q_0$ ,  
 $W^+=(3-1)W_0^+=2W_0^+$ ,  $W_0^+=(3-2)W_0^-=W_0^-$ ,  $R=2R^0$   
 $R_n= nR_0 \sim 2^n$  for the large number of bunches

# *Experiment @ AWA*

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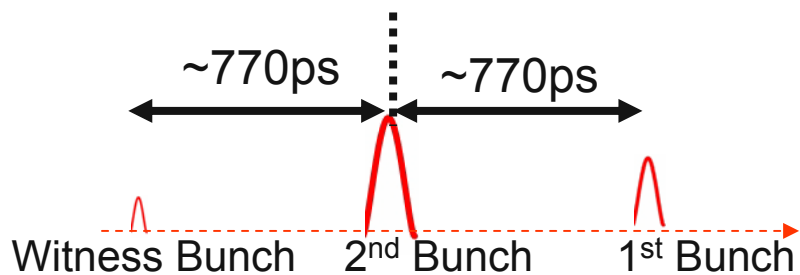
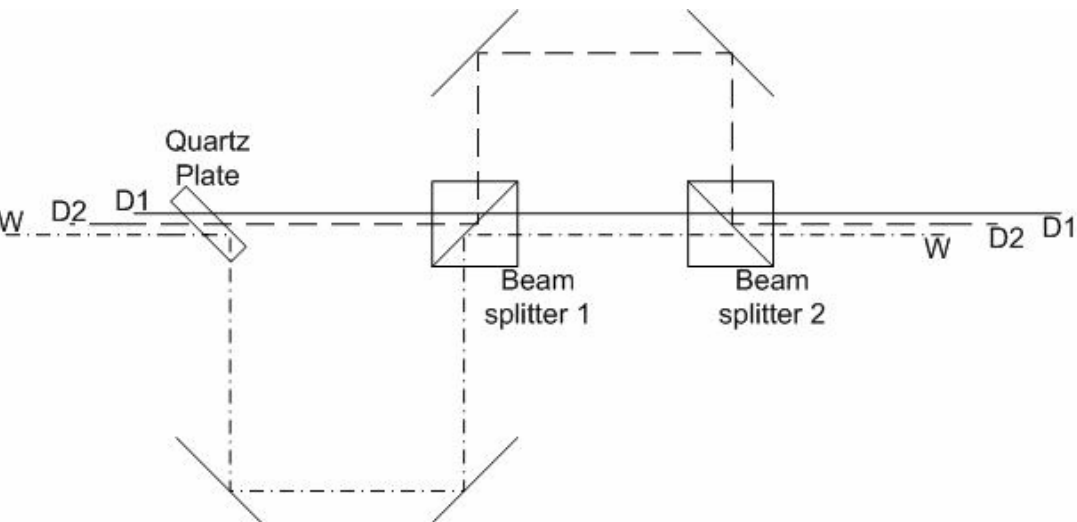
## Experimental goal:

- Measure transformer enhancement of two bunches with ramped the charge ratio.

## Experimental design:

- laser multisplitter producing a ramped train of laser pulses
- 13.625 GHz dielectric loaded accelerating structure
- direct wakefield signal measurement setup
- energy spectrometer to measure energy gain/loss
- set up witness beam to probe wakefield peak behind bunches

# Bunch Train Generator



Based on the bunch length of AWA facility, the charge ratio should be **1:2.5** to reach the maximum transformer ratio enhancement.

# 13.625GHz DLA

## Geometric and accelerating parameters

parameters	value
Freq.	13.625GHz(10.5×1.3GHz)
Dielectric const.	16
Beam hole (diameter)	10mm
Dielectric thickness	1.34mm
Dielectric length	400mm
Group velocity	0.1c
Shunt impedance	13.7MΩ/m
R/Q	5921 Ω/m
Power attn	5dB/m

\* Loss tangent is  $10^{-5}$

## Components before assembly

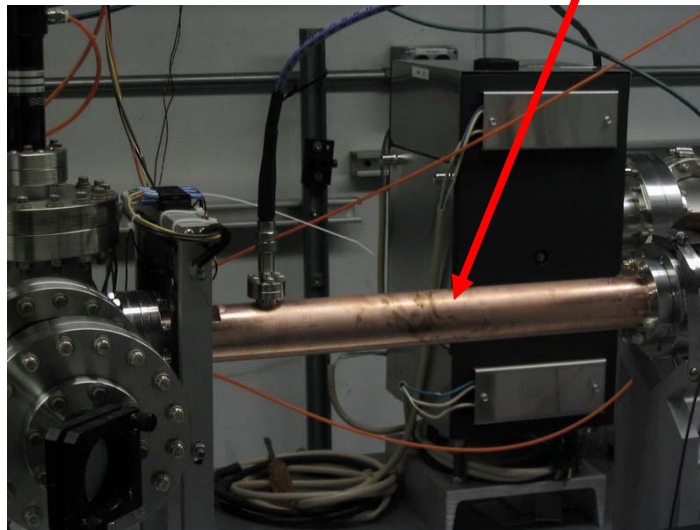
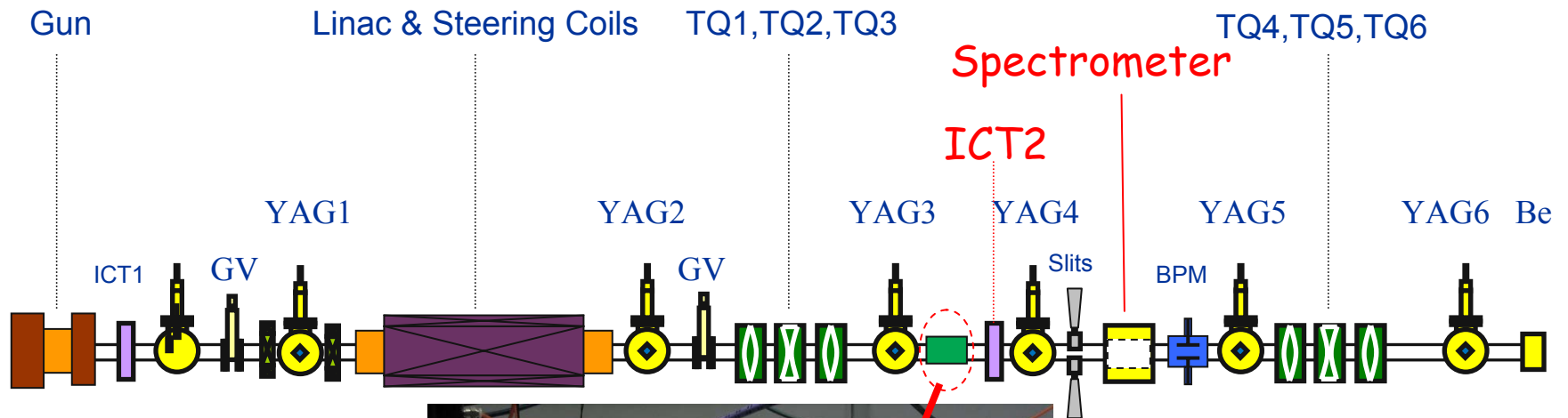


Copper housing



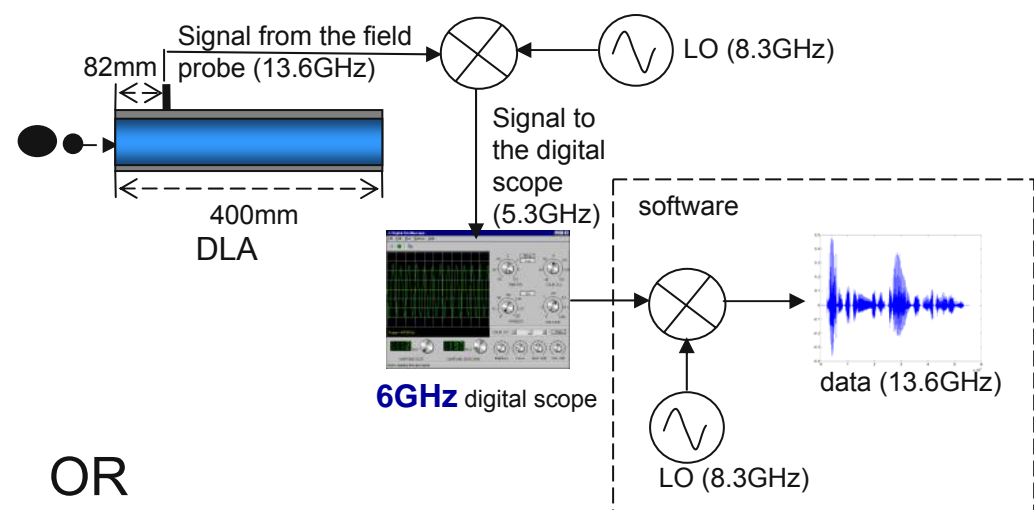
Dielectric tube

# AWA Beamline

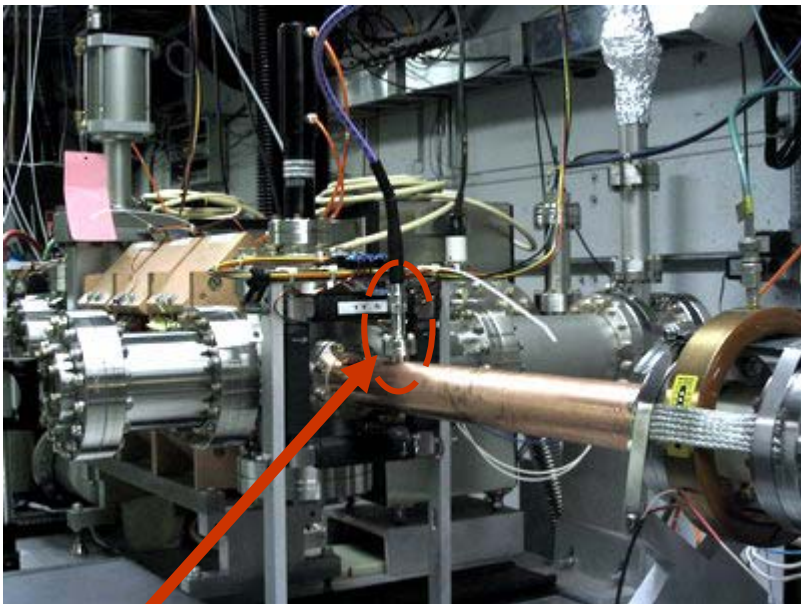
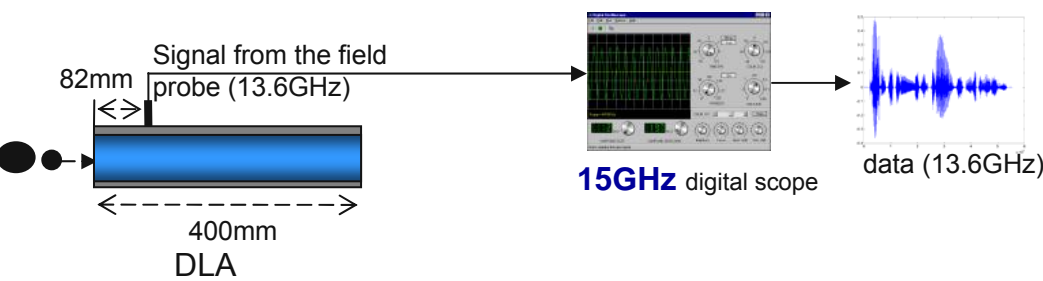




# RF Wakefield Measurement Technique



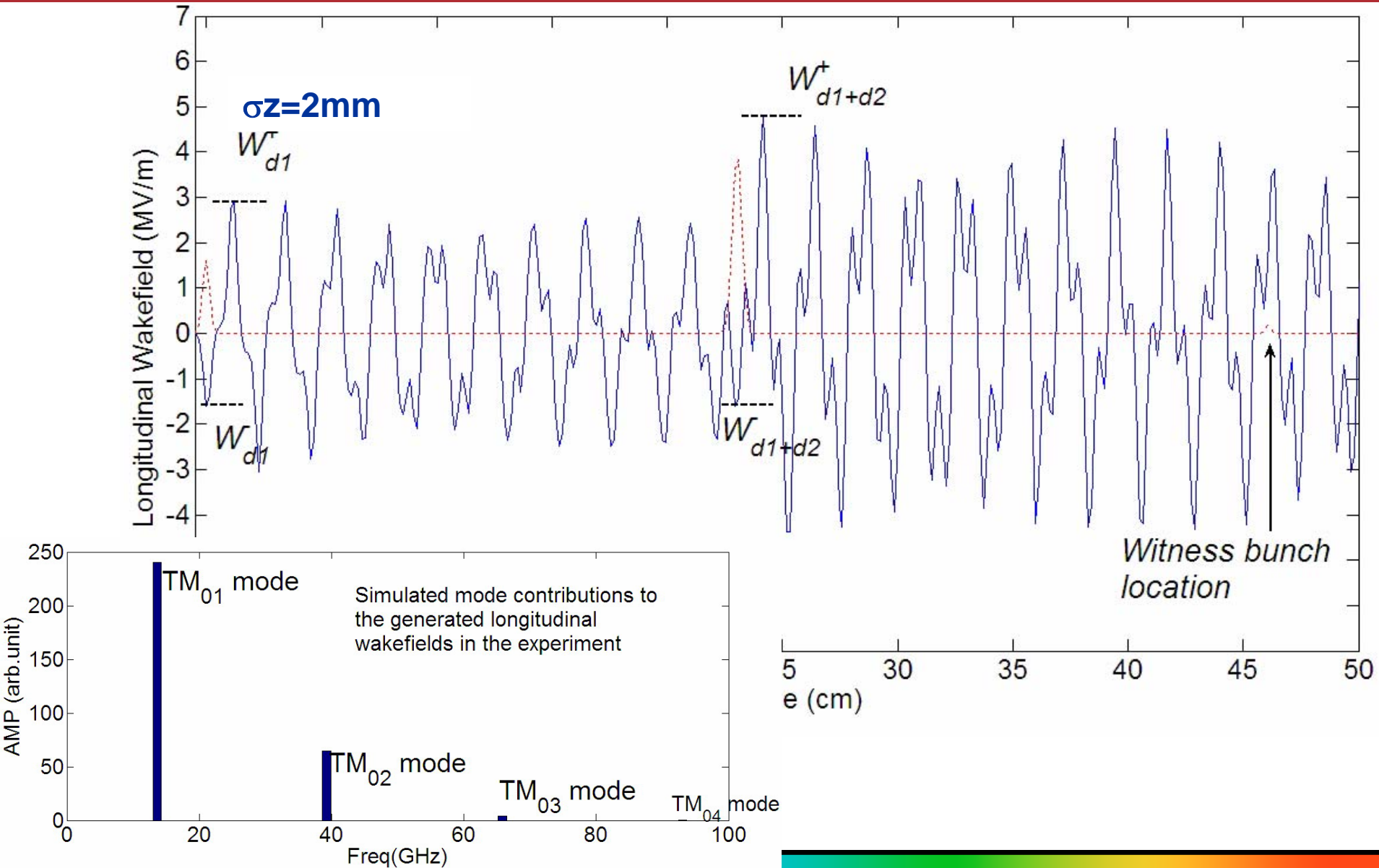
OR



Field Probe

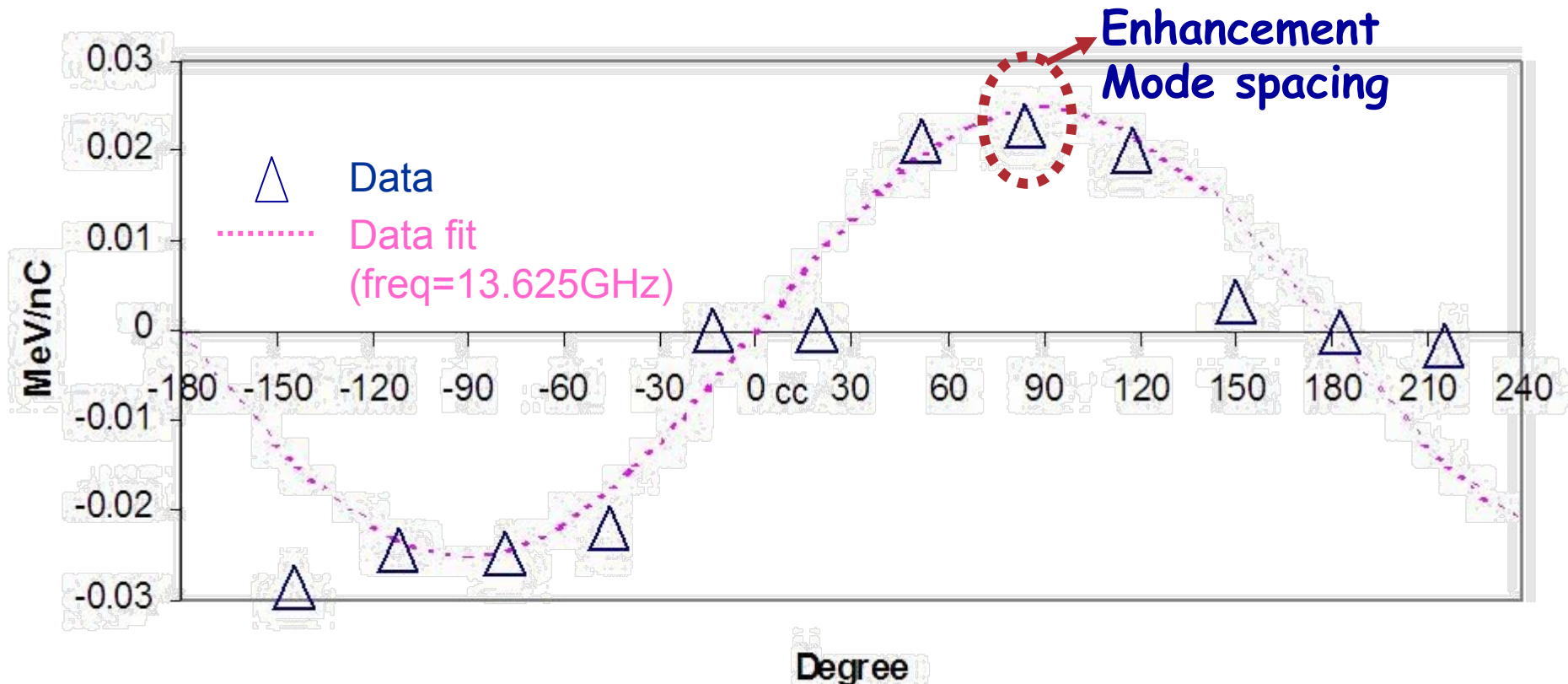
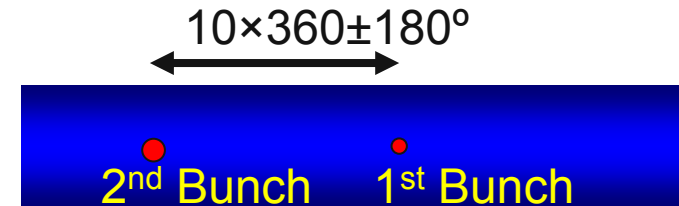


# Experiment Simulation (2 ramped bunches)



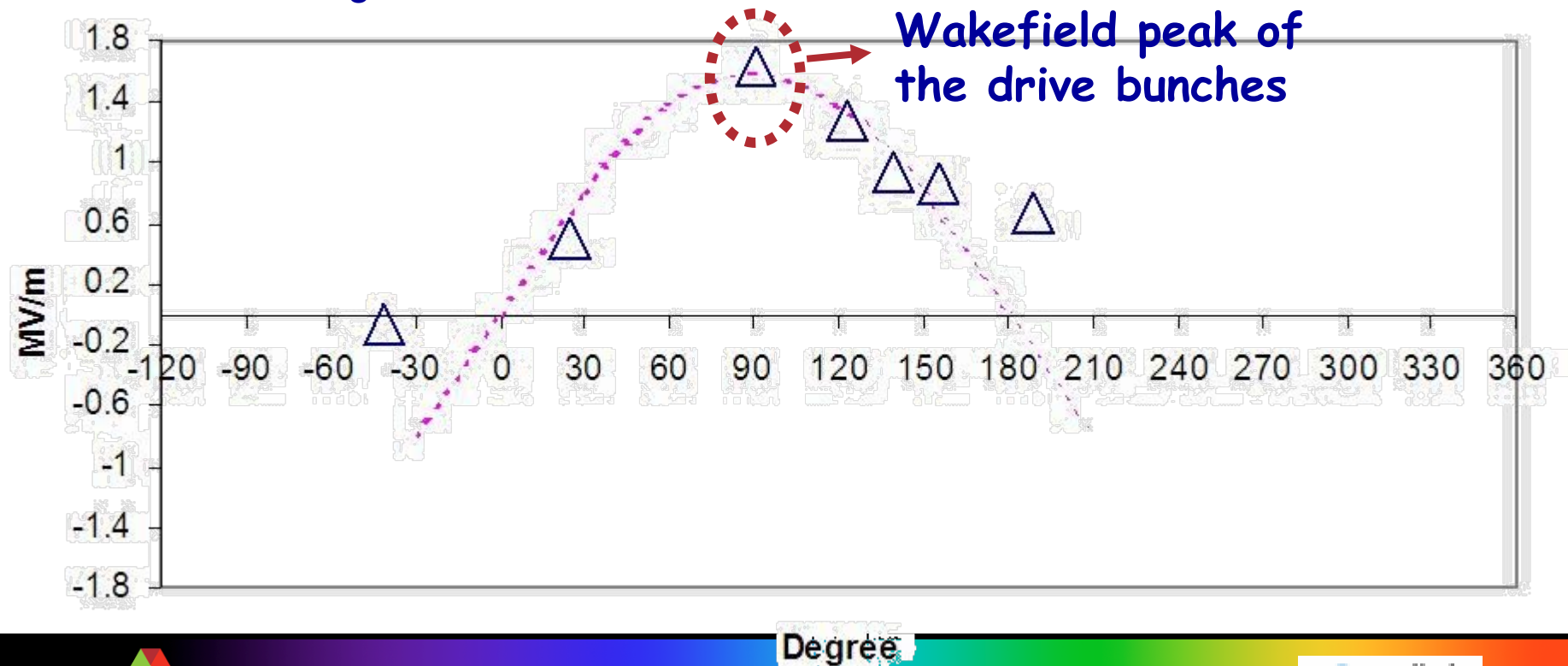
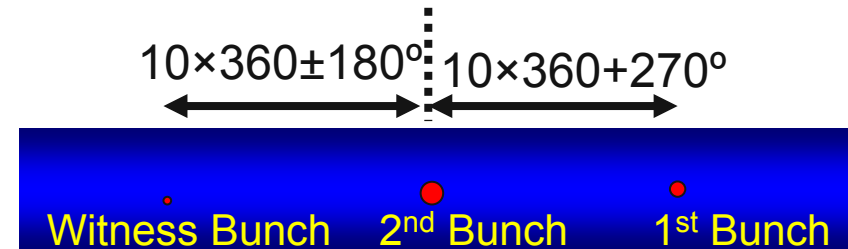
# Normalized Energy Change of the 2nd Drive Bunch

Measured energy change of the 2<sup>nd</sup> drive bunch at different spacing between the two drive bunches.

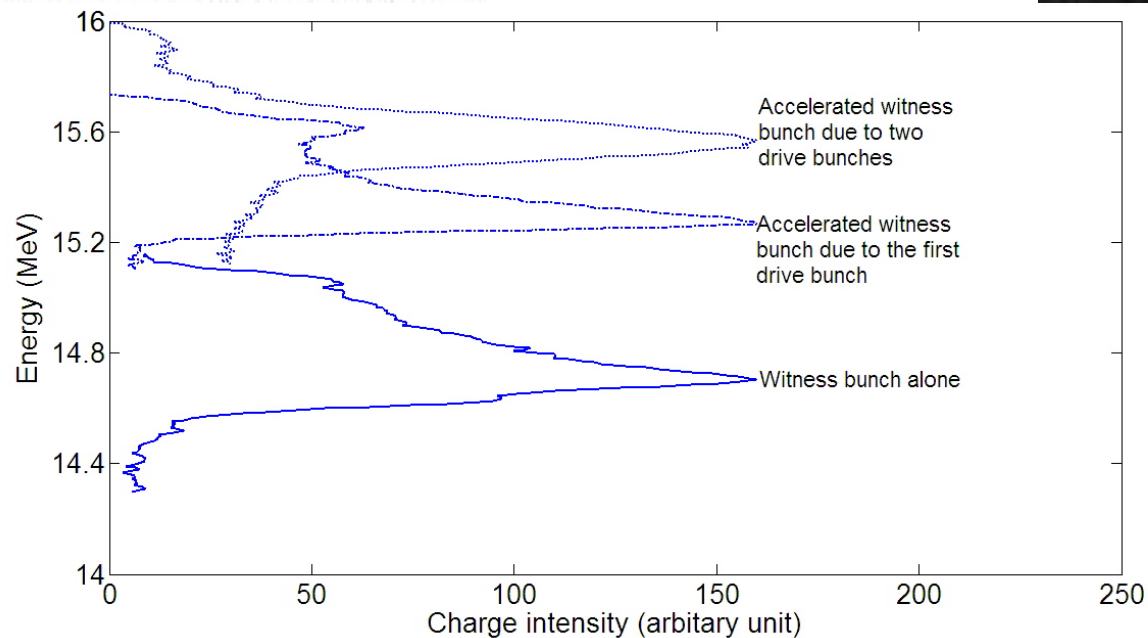
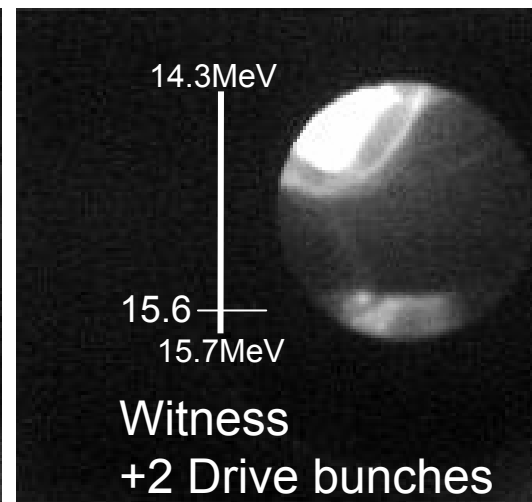
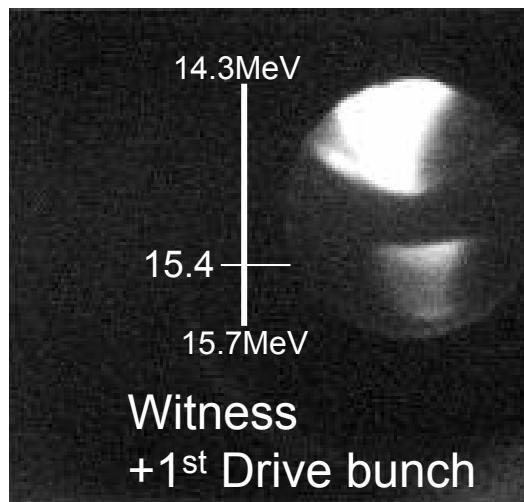
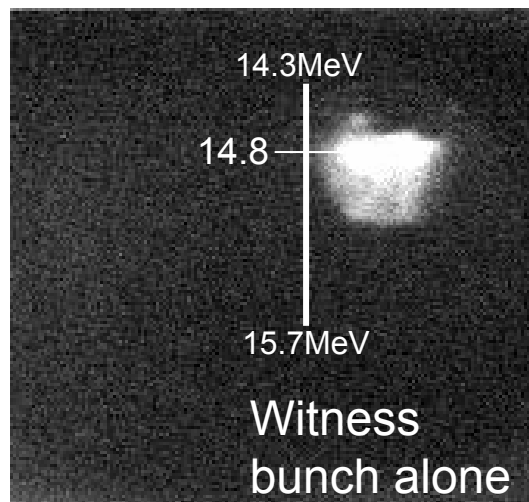


# Witness Beam to Probe the Wakefield Behind Drive Bunches

Measure energy change of the witness beam to find the peak of the wakefield behind the drive bunches so that we can measure the ratio of the wakefield from both drive bunches to single drive bunch



# Measure Transformer Ratio (II)



# Measure Transformer Ratio (III)

Conclusion:

$$\frac{Q1}{Q2} = \frac{1}{2.5} \text{ from measurement}$$

⇓

$$\frac{W^+_{d1}}{W^-_{d1}} = 1.8$$

*from simulation*

$$\frac{W^-_{d1+d2}}{W^-_{d1}} = 1$$

$$\frac{W^+_{d1+d2}}{W^+_{d1}} = 1.31 \pm 1.3$$

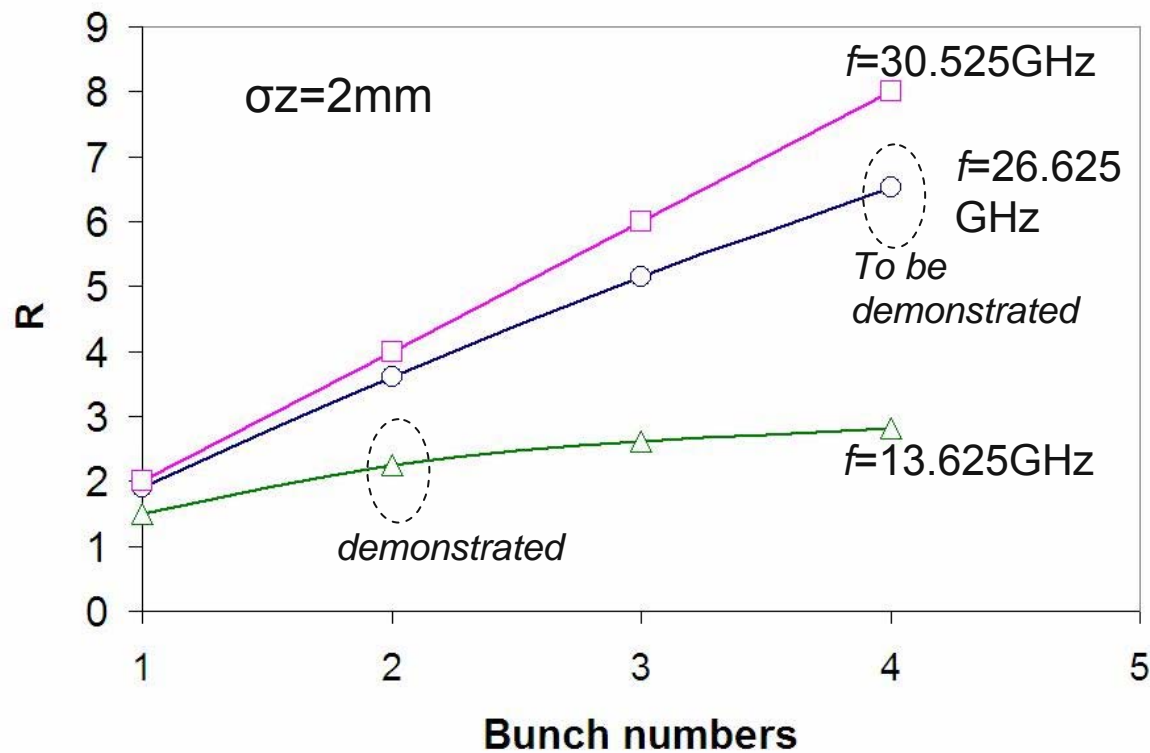
*from measurement*

➤ Transform Ratio  $R$  was enhanced for two ramped bunches is 3 in theory and 2.3 in measurement.

# Relations

$$Q_n = (1 + R_{n-1})Q_1 \quad \left. \vphantom{Q_n} \right\} \Rightarrow R_n = R_{n-1} + (R_1 - 1)^{n-1} R_1 \quad n = 2, \dots, N$$

Half integer spacing





# Summary

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## Accomplishments

- We built a 13.625GHz DLA
- We generated ramped bunch train (2 bunch)
- We measured the transformer ratio enhancement

## Experiment improvement

- Build a new 26GHz structure to reach the optimized bunch length vs. rf wavelength (ceramic tube is under fabrication).
- Try more driving bunches